NEWS NASA
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546
TELS. WO 2-4155
WO 3-6925

FOR RELEASE: TUESDAY P.M.
June 28, 1966

RELEASE NO: 66-163

REPORT ISSUED

ON GEMINI 8

EXPERIMENTS

The National Aeronautics and Space Administration has issued a report detailing results of experiments carried on the Gemini 8 mission. The mission ended last March 16 after 10 hours and 42 minutes of its scheduled three-day flight.

Although the duration of the mission was shorter than scheduled, objectives of some of the experiments were partially achieved.

The mission was terminated after the Gemini 8 spacecraft successfully completed a rendezvous and docking with an Agena target vehicle. An electrical short circuit in the spacecraft caused continuous firing of a roll thruster and the spacecraft crew used the reentry control system to regain control. The crew made an accurate guided reentry and landed in the Pacific Ocean 500 miles east of Okinawa.

Data were received in three of the 10 experiments carried on Gemini 8 and a fourth experiment is still on the Gemini 8 Agena target vehicle. The Agena experiment is scheduled to be recovered on a later Gemini flight.

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The three experiments which provided data include:

Bioassays of Body Fluids -- Two post-flight blood samples were received from each flight crew member. An inflight urine sample was collected from the command pilot and samples were taken from the crewmen after the flight. These samples will be useful in establishing a data point as part of a continuing program to assay the flight crew's response to space flight.

Frog Egg Growth -- Frog eggs are known to orient themselves with respect to gravity during early development. The Gemini 8 data indicates that, when this force of gravity is reduced to near zero, fertilized frog eggs divide normally.

Nuclear Emulsion Experiment -- Telemetry indicated that the experiment was working satisfactorily and has completed about 17 per cent of its "steps" when the flight was terminated. Because the flight ended before the extravehicular activity, the experiment was not recovered from the spacecraft retrograde adapter section.

The Gemini 8 experiments report is attached.

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GEMINI 8 MISSION
EXPERIMENTS REPORT
June 23, 1966

Ten scientific, medical, and technological experiments, as listed in table 8.0-I, were planned for the Gemini VIII mission. The purpose of these experiments was to extend man's knowledge of space and to further develop the ability to sustain life in the space environment.

Because the duration of the Gemini VIII mission was only 10 hours instead of the planned 3 days, none of the experiment objectives were fully achieved.

TABLE 8.0-I.- EXPERIMENTS

Experiment number	Experiment title	Principal experimenter	Sponsor
D-3	Mass Determination	Deputy for Technology Headquarters, Air Force Space Systems Division, Los Angeles, California	Department of Defense
D-14	UHF/VHF Polarization	U.S. Naval Research Laboratory, Washington, D.C.	Department of Defense
D-15	Night Image Intensification	U.S. Naval Air Development Center, Johnsville, Pennsylvania	Department of Defense
D-16	Power Tool Evaluation	Air Force Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio	Department of Defense
M-5	Bioassays Body Fluids	Space Medicine Branch, Crew Systems Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
S-1	Zodiacal Light Photography	School of Physics, Institute of Technology, University of Minnesota, Minneapolis, Minnesota	Office of Space Sciences
S-3	Frog Egg Growth	Ames Research Center, Moffett Field, California	Office of Space Sciences
S-7	Cloud Top Spectrometer	National Weather Satellite Center, U.S. Weather Bureau, Suitland, Maryland	Office of Space Sciences
S-9	Nuclear Emulsion	Naval Research Laboratory, Washington, D.C. Goddard Space Flight Center, Greenbelt, Maryland	Office of Space Sciences
S-10	Agena Micrometeorite	Dudley University, Albany, New York	Office of Space Sciences

8.1 EXPERIMENT D-3, MASS DETERMINATION

8.1.1 Objective

The objective of this experiment was to test the technique and accuracy of a direct-contact method of determining the mass of an orbiting object.

The method would have involved accelerating the Gemini Agena Target Vehicle (GATV) by pushing it with the spacecraft. The mass of the GATV would be calculated from the resultant acceleration, spacecraft mass, and thrust level.

8.1.2 Equipment

No special spacecraft or GATV equipment was needed for this experiment.

8.1.3 Procedure

The experiment would have been evaluated by utilizing two independent methods: (1) the flight-crew method (inflight calculations performed by the flight crew), and (2) telemetered method (calculations performed on the ground utilizing telemetered data).

The flight crew would have performed the before-docking portion of the experiment by thrusting the spacecraft for 7 seconds using the aft-firing thrusters. The delta velocity (incremental velocity read from the onboard computer) and delta time (thrusting time over which the delta velocity is measured) with an updated spacecraft mass was to be used to compute the maneuvering thrust:

$$F = Ma = M_G \frac{\Delta V}{\Delta t} \tag{1}$$

where

F = thrust in pounds

M_G = mass of Gemini spacecraft in slugs

V = forward velocity in ft/sec

t = time in seconds.

The after-docking portion of the experiment would have been performed by thrusting the rigidized spacecraft—GATV combination for 25 seconds using the spacecraft aft-firing thrusters. The delta velocity and delta time was to have been taken from the last 7 seconds of the 25-second burn. With the spacecraft mass (M_G) and the maneuvering thrust (F) (equation 1) the mass of the GATV could be computed:

$$M_A = F \frac{\Delta t}{\Delta V} - M_G \qquad (2)$$

where

M_A = mass of the GATV in slugs

The before-docking maneuvering thrust and the after-docking GATV mass would also have been computed on the ground, utilizing telemetered information.

8.1.4 Results

Difficulties encountered with the spacecraft forced termination of the mission prior to any attempt of this experiment.

8.2 EXPERIMENT D-14, UHF/VHF POLARIZATION

8.2.1 Objective

This experiment was to measure the electron content of the ionosphere below the spacecraft by means of a dual-frequency Faraday rotation system utilizing two satellite-borne transmitters operating near 130 and 400 Mc. The principal purpose was to measure the inhomogeneities in the electron content which exist along the orbital path and to gain insight into the structure of the low ionosphere and its temporal variation. The geophysical and temporal correlation analyses which were to have been conducted would have aided in the prediction of the frequency and magnitude of ionospheric disturbances which might have occurred.

8.2.2 Equipment

The D-14 equipment consisted of a continuous-wave (CW) transmitter chassis, diplexer monopole antenna, and a dipole antenna boom, all located in the spacecraft adapter assembly.

8.2.3 Procedures

Each time the spacecraft approached the radio horizon of the ground station at Hawaii and the ground station at Antigua, the flight crew would have been required to position the spacecraft so that the antenna pointed toward the center of the earth. The antenna boom would have been extended prior to transmitting data. During each pass over Hawaii and Antigua, the flight crew would have maneuvered the spacecraft so as to maintain the antenna pointing toward the center of the earth as accurately as possible. After passing beyond the radio horizon or the line-of-sight to the station, the flight crew would have turned off the transmitters.

8.2.4 Results

Difficulties encountered with the spacecraft forced termination of the mission prior to any attempt of this experiment.

8.3 EXPERIMENT D-15, NIGHT IMAGE INTENSIFICATION

8.3.1 Objective

The objective of this experiment was to aid in the development of a system for night surveillance of the sea and terrestrial features. The system would have been used for night viewing of various objects and for observation of airglow, sea state, and weather data. A three-way comparison would have been made of each scene: (1) one flight crewman looking directly at the scene, (2) the other crewman looking at a television viewing monitor, and (3) by later examining the televised scene as recorded on photographic film.

8.3.2 Equipment

The equipment for this experiment consisted of a television camera, camera control, viewing monitor, recording monitor and photographic camera, and monitor electronics and equipment control. The television camera and camera control were located in the spacecraft adapter assembly and were not recovered.

8.3.3 Procedures

This experiment called for spacecraft flight attitudes such that both the flight crew and the television camera viewed the same earth scene simultaneously. This required that the spacecraft longitudinal axis be approximately normal to the surface of the earth for each of the experiment tasks. In some cases it would have been necessary for the crew to orient the spacecraft in an attitude which would enable a specific target to be acquired in the television camera's field-of-view as the spacecraft approached the zenith of the target. Upon acquiring the target, the flight crew would have controlled the spacecraft's angular rate in order to track the target and record the scene for a period of approximately 60 seconds. Other tasks required only that the spacecraft longitudinal axis be aligned normal to the surface of the earth and also scanned from this attitude to an attitude where the horizon would have been just visible.

8.3.4 Results

Difficulties encountered with the spacecraft forced termination of the mission prior to any attempt of this experiment.

8.4 EXPERIMENT D-16, POWER TOOL EVALUATION

8.4.1 Objective

The objective of this experiment was to investigate man's capability to perform work under true space conditions. Tests were performed in a KC-135 airplane flying a zero-g trajectory to determine the capability of an unrestrained man to perform work tasks with conventional tools. These tests confirmed beliefs that, due to weightless and resultant frictionless conditions, attempts to transmit torques and forces as tool outputs would be returned to the operator as reactive forces. In attempts to overcome the reactive forces on the operator, two basic methods have been under study: (1) physical restraint attachments such as handholds, belts, and harnesses, to restrain the reactive forces on the man, and (2) tools which internally balance the reactive forces to which the operator would otherwise be subjected.

It is believed that the second method mentioned is the better of the two approaches. A minimum-reaction power tool has been developed and tested, and has proven to be satisfactory. This tool was to have been used in Experiment D-16.

8.4.2 Equipment

The equipment for this experiment consisted of a space power tool, power-tool battery, hand wrench, and a tool restraint box in the spacecraft adapter assembly, plus a knee tether stowed in the crew compartment.

8.4.3 Procedures

The pilot would have egressed from the spacecraft and moved to the tool work panel located on the retroadapter. He would have then attached himself to the work site with the knee tether, removed the minimum-reaction power tool from the restraint box, and performed the specific work tasks on the prearranged work panel. Upon completion of the work tasks, he would have returned to the spacecraft cabin.

8.4.4 Results

Difficulties encountered with the spacecraft forced termination of the mission prior to any attempt of this experiment.

8.5 EXPERIMENT M-5, BIOASSAYS BODY FLUIDS

8.5.1 Objective

The objective of this experiment was to use hormonal assays to determine the reaction of the flight crew to the stress requirements of space flight. Before and after the flight, two or three daily plasma samples and time urine samples were to be obtained. Urine samples were to be collected during the flight and stored along with a preservative. The crew would record the time and volume of each sample.

8.5.2 Equipment

During flight, urine would be sampled with a urine-sampling and volume-measuring system, which consisted of a valve with a tritiated water injector, a mixing bag, and 24 sample bags.

8.5.3 Procedures

Prior to urination, a precise volume of tritiated water was to be injected into the lines of the valve by a positive displacement pump incorporated into the valve. Urine would wash the tritium into the mixing bag. A sample of the urine containing tritium would then be transferred through the valve from the mixing bag to a sample bag. The sample bag would then be removed and stored. The total volume of each voiding would then be determined postflight by measuring the dilution of the tritium isotope.

8.5.4 Results

The M-5 experiment equipment was not unstowed during this mission, but certain samples were received that will be useful for future analysis and evaluation.

Two postflight blood samples were received from each flight crew member. A used urine-collection device (UCD) was recovered from the command pilot; the pilot did not use his UCD. Two postflight urine samples were received from the pilot and one from the command pilot.

8.6 EXPERIMENT S-1, ZODIACAL LIGHT PHOTOGRAPHY

8.6.1 Objective

The objective of Experiment S-1 was to obtain photographs of the Zodiacal light, the airglow, and the gegenschein. Long exposures are required to photograph these dim-light phenomena.

8.6.2 Equipment

The experiment equipment consisted of a modified 35-mm camera with mounting brackets to position it in the cabin window.

8.6.3 Procedures

The spacecraft was to have been placed in the proper attitude for pictures which was to have been blunt-end forward (BEF) with the crew looking back along the orbit or, more specifically, looking approximately West at the point where the sun sets. Zero to 10 degrees pitch down would have been acceptable, from where a 40-to-50 degree yaw to the left, or toward South, would have placed the desired portion of the sky in the field of the camera.

The camera was to have been taken from the stowed position and mounted in the cabin window. The camera included an electronic device to program the exposure according to a predetermined sequence. This sequence would have started automatically at sunset. After completion of photography, the camera was to have been removed from the mount and restowed.

8.6.4 Results

Difficulties encountered with the spacecraft forced termination of the mission prior to any attempt of this experiment.

8.7 EXPERIMENT S-3, FROG EGG GROWTH

8.7.1 Objective

The objectives of Experiment S-3 were to determine the effect of weightlessness on the ability of the fertilized frog egg to divide normally and to differentiate and form a normal embryo.

8.7.2 Equipment

The experiment was contained in two identical packages, one of which was mounted on each hatch of the spacecraft. Each package had four chambers containing frog eggs in water, with a partitioned section containing a fixative (5-percent formalin). Each package was insulated and contained temperature-control systems for both heating and cooling in order to maintain an experiment temperature of close to 70° F. Electrical power was obtained from the spacecraft Electrical System. The experiment was actuated by handles provided on the outside of each package. These handles and a switch for the heating element were manipulated by the adjacent flight crewman, either on ground command or according to a predetermined schedule. Identical hardware was used for control experiments on the ground.

8.7.3 Procedure

Eggs were obtained from several dozen female frogs (Rana pipiens) by injection of frog pituitary glands about 48-hours prelaunch, in order to induce ovulation. The best of these eggs (from two females) were selected for flight and fertilized by immersion in a sperm suspension made by macerating frog testes in pond water. The fertilized eggs were then removed to a 43° F cold room and placed in about 10 cc of pond water in the experimental chambers. The fixative was placed behind leak-proof partitions in the chamber. Each chamber received from 5 to 8 eggs, so that a total of 52 eggs were carried in the spacecraft. Two sets of controls were set up in identical hardware on the ground. The first was to run simultaneously with the flight, and the second was delayed about 2 hours so that changes in temperature experienced by the flight experiment could be duplicated on the ground more precisely than in the simultaneous control. Since telemetered temperatures were not received instantaneously, such a delayed control was necessary.

The flight experiment was placed in the spacecraft about 4 hours before launch. By keeping the fertilized eggs at about 43° F until this time, the first division of the eggs was retarded. It was hoped

that this pre-cooling of the eggs would be sufficient to retard first cleavage until the zero-g phase of the flight. At approximately 40 minutes ground elapsed time (g.e.t.), the pilot was to turn the first handle on the right-hand experiment package, which would inject the fixative into the egg chamber, killing the eggs in that chamber and preserving them for microscopic study on recovery. A second handle was to be turned at 2 hours 10 minutes g.e.t., which would fix the remaining two chambers at about the eight-cell stage. Two chambers in the left-hand package were to be fixed at the end of the 3-day flight, just before reentry. The last two chambers were to remain unfixed and those embryos returned alive. All eggs and embryos were to be studied upon recovery for gross morphological abnormalities in cleavage planes and differentiation. Histological examination and electron microscopy were also anticipated.

8.7.4 Results

Although the cabin temperatures were considerably above the predicted 70° F, the temperature control system on the experiment packages was sufficient to retard first cleavage until the zero-g phase of the flight. Thus, the first fixation, at 40 minutes g.e.t., was successful in stopping development between first and second cleavage. The flight crew were also able to perform the second activation at 2 hours 25 minutes g.e.t. (15 minutes late) which was at about the eight-cell stage of development. Because of difficulties with the spacecraft, the flight was terminated after about 10 hours and the remainder of the experiment could not be accomplished. Thus, only the first half of the experiment was completed successfully. The fixed eggs in the first four chambers appeared identical in all respects when compared to the controls. The cleavage planes appeared normal and to have been proceeding on schedule. Histological and electron microscope study may show some abnormalities but this is not anticipated. The absence of a gravitational field does not appear to have any effect on the ability of the frog egg to divide normally during its early stages, when such an effect would be most likely to occur because of the large density gradient in these cells.

8.7.5 Conclusions

In spite of the fact that the frog egg is known to orient itself with respect to gravity during its very early development, a gravitational field is apparently not necessary for the egg to divide normally. Whether this independence from, gravity applies to differentiation and morphological changes in later stages was not demonstrated because of the short duration of the flight. Whether the egg will divide normally if it

is fertilized in zero-g, so that the egg never has a chance to become oriented with respect to gravity, is also unanswered at this time. It is hoped that these two very important questions can be answered in later flights.

8.8 EXPERIMENT S-7, CLOUD TOP SPECTROMETER

8.8.1 Objective

The objective of this experiment was to use a simple hand-held spectrograph to investigate the possibility of using satellites to measure cloud-top altitudes.

8.8.2 Equipment

The equipment consisted of a spectrograph fitted with a 35-mm camera body.

8.8.3 Procedures

The spectrometer would have been removed from stowage and the shutter released. This would waste one frame of film but it would have placed the shutter mechanism in its proper position. The entrance aperture of the spectrometer was located 4 inches to the left of the view finder. The exposure times for the spectrograph were 1/4 and 1/8 of a second. One exposure would have been made of sunlight being reflected from a 6-inch by 6-inch card.

For each picture a voice report would have been made giving:

(a) The ground elapsed time

(b) A brief description of cloud formation (cirrus, stratus, etc.)

(c) An estimate of the azimuth angle from the North or from the sun

(d) An estimate of the angle of depression between horizon and the cloud.

8.8.4 Results

Difficulties encountered with the spacecraft forced termination of the mission prior to any attempt of this experiment.

8.9 EXPERIMENT S-9, NUCLEAR EMULSION

8.9.1 Objective

The objective of this experiment was to contribute new knowledge to the fields of space science, astrophysics, and high-energy-particle physics. Cosmic rays provide a means for investigating nuclear interactions and electromagnetic acceleration and transmission mechanisms within the galaxy, and possibly beyond.

8.9.2 Equipment

The experiment equipment consisted of a nuclear emulsion package which was stowed in the spacecraft retrograde adapter section during launch and orbit.

8.9.3 Procedures

A major procedural requirement in the conductance of this experiment would have been to keep the spacecraft attitude in the proper orientation; however, attitude needed to be held only within ±10 degrees. The horizon-scanner mode of attitude control would have been sufficient for this accuracy. It would also have been necessary to orient the spacecraft so that the top face of the emulsion package laid in a plane which was normal (±10 degrees) to the earth's average magnetic field vector ($\underline{f}$) anytime the spacecraft was in the vicinity of the South Atlantic magnetic anomaly. This orientation will be referred to as the anomaly orientation.

Operations performed or to have been performed by the flight crew were as follows:

(a) The hinged cover, used to protect the experiment during launch, was opened remotely.

(b) The experiment was switched from OFF to mode 1 operation at a specified time after insertion into orbit. Further instructions for turning the experiment on and off were to have been provided as the mission plan developed.

(c) The spacecraft was to have been put into anomaly orientation each time it passed through the South Atlantic anomaly.

(d) The mode 1 operation was monitored by real-time telemetry. No mode 2 operation was planned unless mode 1 malfunctioned.

(e) If the crew found it no longer possible to maintain the exposure orientation, they were to have moved the switch to the mode 2 position, left it there for at least 15 seconds, and then returned it to the OFF position. This operation would have advanced the stack to the next background position. When exposure orientation was again possible for a period of at least 30 minutes, the switch was to have been returned to the mode 2 position for 15 seconds and then reset to the OFF position, again moving the package to the next data position.

(f) The crew was requested to report the times at which all of the preceding actions were taken.

(g) During the planned EVA, the emulsion package would have been removed from the retroadapter and placed in the insulated container in the cabin.

8.9.4 Results

Telemetry channels were functioning satisfactorily prior to lift-off. At 00:23:00 g.e.t., the experiment was turned on. At 01:40:00 g.e.t., telemetry was indicating proper translations of the moving stack. At 03:10:00 g.e.t., telemetry indicated that the stack was still stepping properly and had completed approximately 200 of the 2000 steps. Controlled temperatures of this experiment were satisfactorily maintained between 40° and 46° F. At 06:19:00 g.e.t., telemetry indicated that the stack had moved through about 17.8 percent (360 steps) of its full travel (2000 steps) and was still functioning according to design, and that the temperature control was satisfactory.

Difficulties encountered with the spacecraft forced termination of the mission prior to EVA, and, as a result, the S-9 experiment was not recovered.

8.10 EXPERIMENT S-10, AGENA MICROMETEORITE COLLECTION

8.10.1 Objective

The objective of this experiment was to expose specially prepared and polished surfaces to the small-particle flux of the upper atmosphere and near-earth space environment, in an effort to gain useful knowledge of the impact and cratering properties of these small particles in space.

8.10.2 Equipment

The equipment consisted of a micrometeorite collector located on the Gemini Agena Target Vehicle (GATV).

8.10.3 Procedures

During EVA, the micrometeorite unit, located on the GATV, would have been opened to expose the collecting surface. If an attempt to rendezvous with the Gemini VIII GATV during the Gemini X flight had not been planned, the micrometeorite unit could have been retrieved, placed in a plastic bag, and stowed onboard the Gemini VIII spacecraft for reentry.

8.10.4 Results

Difficulties encountered with the spacecraft precluded any EVA or full experiment deployment. The experiment package remains on the GATV for possible recovery during future missions.

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